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E. W. Bird
Iowa State College

H. W. Sadler
Iowa State College

C. A. Iverson
Iowa State College

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By E. W. Bird, H. W. Sadler and C. A. Iverson

AGRICULTURAL EXPERIMENT STATION
IOWA STATE COLLEGE OF AGRICULTURE
AND MECHANIC ARTS

R. E. Buchanan, Director

DAIRY INDUSTRY SECTION

AMES, IOWA

SUMMARY AND CONCLUSIONS

1. The body and texture of ice cream are improved by the replacement of dry skimmilk by sodium caseinate sols. This improvement was shown up to 2.5 to 5.0 percent replacement, depending on the composition of the mix.
2. The flavor of ice cream was progressively improved by the replacement of dry skimmilk by sodium caseinate sols up to 3 to 4 percent replacement, depending on the composition of the mix.
3. This flavor improvement was due to the careful pH control used in the preparation of the sodium caseinate sols.
4. The type of melting of the ice cream was altered by the replacement of dry skimmilk by sodium caseinate sols.
5. The use of sodium caseinate sols increased the initial and maximum overrun and decreased the whipping time of the ice creams produced.
6. The curves for whipping time show that from 1.5 to 3.0 percent replacement of dry skimmilk by the sodium caseinate sols is necessary to effect sufficient improvement in whip to warrant their use. A 3 percent replacement would be necessary with a mix containing 14 percent fat and 10 percent serum solids.
7. The use of sodium caseinate preparations as additional solids, i.e., in addition to the amounts of serum solids (8 to 10 percent) commonly used by the trade, has been suggested. The amounts of milk protein that would be required to yield sufficient improvement in whip and in body and texture score would, in the light of the figures presented, be large enough to make their use questionable.

The Preparation of a Non-Desiccated Sodium Caseinate Sol[1] and Its Use In Ice Cream[2]

By E. W. Bird, H. W. Sadler and C. A. Iverson

Continuous and serious efforts have been made by individuals interested in ice cream manufacture to improve the physical characteristics of the product, especially to effect a smoother texture. The means employed to obtain such improvement are these: (1) Mechanical manipulation of the mix (homogenization, high temperature pasteurization and more rapid freezing methods, as with the direct expansion and the "continuous" freezers) and (2) changes in the composition of the mix (inclusion of gelatine and increase of percentage of serum solids).

Increasing the serum solids percentage has brought with it, under certain conditions, sandiness and heavy or gummy body. To eliminate or minimize the occurrence of sandiness resulting from an increase of serum solids, methods have been advanced, from time to time, for the removal of lactose from dairy products, so that when these products are used as added solids sandiness will not develop in the ice cream.

Approximately 3½ years ago there were indications that delactosed dried milk proteins might be offered to the trade in this area as a means of increasing solids and obtaining smoother texture in ice cream—as a means of manufacturing a product comparable in texture to that obtained with the continuous freezer. For that reason the investigation reported herein was initiated. The purpose of the study was to obtain information which would show whether the use of milk proteins as added solids (in amounts that would not produce a gummy body) would improve the product sufficiently to warrant use of these products.

LITERATURE REVIEW

Two general types of casein are on the market—namely, acid and rennet. Rennet casein differs somewhat in composition and behavior from acid casein. It is not generally used, except in the manufacture of plastic casein products, because of its extremely high ash content and its inactivity. The acid caseins may be divided into three classes: Natural sour or lactic, hydrochloric and sulfuric. These classes may be further subdivided with regard to variations in the methods of manufacture. The hydrochloric acid grain curd and the sulfuric acid cooked curd

[1] The use of this product in ice cream is covered by the Zoller patent (12).
[2] Project No. 339 of the Iowa Agricultural Experiment Station.

processes are the two most important modifications of the methods of manufacture involving acids.

Clark, Zoller, Dahlberg and Weimar (3) introduced the grain curd process for raw skimmilk. Zoller (11) modified the grain curd method for use with pasteurized skimmilk. In this process the casein is precipitated with dilute hydrochloric acid at temperatures varying from 35°-52° C., depending on the temperature and the length of time of pasteurization. The fine granular curd obtained is washed several times with acidified water (pH 4.8). It is then drained, pressed and dried.

The method used to precipitate and wash the casein curd in the preparation of sodium caseinate is essentially a modification of the grain curd process. The chief difference between the methods is that lower precipitating and washing temperatures are employed in the latter to obtain a very soft, easily peptized curd. This, of course, required different methods of draining and washing.

Hall and Houtz (4) were the first investigators to use casein in ice cream. They sought, through the use of casein, to raise the serum solids content of ice cream above the usual 10-11 percent without danger of producing sandiness. This quotation from Hall and Houtz (5) gives the reason for their attempt to increase the serum solids:

> "Additional solids-not-fat are not expensive, but very desirable, because they tend to make a finer texture and a smoother product of greater body. It will dip or measure better for a given overrun, is more palatable, and less gelatine may be used. There is no question that the average trade likes the smooth texture."

Hall and Houtz in their experimental work tried to use powdered commercial casein and pure casein, but found that both products were insoluble and, in addition, were sufficiently acid to produce a sour flavor in the ice cream. They next used a soluble casein powder which had an alkaline reaction. A very smooth product with an excellent appearance but a disagreeable alkaline flavor was produced. They found, likewise, that freshly precipitated casein curd was insoluble. This curd, which had been precipitated by hydrochloric acid at 130° F., was washed a number of times to remove all traces of acid. Fifty percent of the moisture was removed by pressure. Their last experiment was with some of this freshly precipitated casein curd which they slowly heated with a 10 percent solution of sodium bicarbonate. Gradually the curd changed its form to a cream colored suspension with but a slightly alkaline flavor. This suspension of "soluble" casein when added to ordinary mixes produced an ice cream which had a very smooth texture and no alkaline flavor. This latter process for making "soluble" casein, however, was not satisfactory because of the high moisture content of the casein (over 50 percent) and because of the acid and alkali retained.

Hall and Houtz concluded that the use of added casein in high solids ice cream would be advantageous if the objections cited could be overcome. They believed a spray-dried delactosed milk would be very desirable for the ice cream industry and suggested centrifuging condensed skimmilk to remove the lactose before it was dried.

Turney (8) patented a casein ice cream filler. The precipitation of the casein curd was induced by pepsin, rennet or acid and then "semidissolved" by the addition of lime, sodium bicarbonate and sugar.

Bogue (1) suggested increasing the protein content by the use of proteins other than gelatine. Such proteins (as milk protein) do not "set to a jelly as does gelatine." This he considered would produce a smoother body.

Zoller (12) patented an "unhydrolyzed" alkali caseinate to be used with the usual ingredients in the ice cream mix.

Leighton and Leviton (6) condensed skimmilk, to which sugar had been added, and centrifuged the product obtained to remove the separated lactose. This method with the exception of the added sucrose, had been suggested previously by Hall and Houtz (4).

Martin (7) concluded from his work that the so-called commercial dry milk proteins do not have any particular advantage over dry skimmilk as a source of serum solids.

Washburn (9) suggested the use of casein-gel (sodium caseinate) in the ice cream mix. He made the suspension from cottage cheese curd by sprinkling 2½ percent (of the weight of the cooked dry curd) of sodium bicarbonate over the curd. The sodium caseinate formed has a neutral or slightly alkaline reaction.

Washburn (10) recommends that the suspension be used as follows:

> "Briefly, the casein-gel may be used about as unsweetened condensed milk would be, and gel-powder about as skim powder would be. We say 'about' because they are best used to replace a part from a quarter to a half only of the serum solids ingredients, not all; and to build up the solids to a higher percentage with safety as to sandiness."

EXPERIMENTAL

METHODS OF PREPARATION OF SODIUM CASEINATE SOLS[3]

The methods outlined below were designed to produce sodium caseinate sols which were of uniform composition and free from off flavors.

EQUIPMENT

The equipment used in the manufacture of sodium caseinate suspension was as follows:

a. Precipitating vats.

[3] The use of this product in ice cream is covered by the Zöller patent (12).

b. Acid jar with siphon.
c. Wash water jar.
d. Siphon for draining whey and wash water.
e. Small colorimetric pH set.
f. Drainage bags.
g. Bag holders.
h. Drain rack.

The equipment listed will be described briefly.

PRECIPITATING VATS

Two 50-gallon vertical ice cream holding vats, equipped with mechanical agitators, were used for this purpose. The small mechanical agitators in these vats produced a uniform curd which settled rapidly and was easily peptized, because relatively little local action occurred between the acid and the milk protein.

ACID JAR WITH SIPHON

A 3-gallon stone jar with a 4-inch neck was used to hold the dilute hydrochloric acid by which the casein was precipitated. This jar was fitted with a glass siphon 1/4 inch in diameter. The rate of flow of the acid was regulated by a short piece of rubber tubing and a screw clamp attached to the outlet of the siphon.

WASH WATER JAR

A 20-gallon stone jar was placed on a wooden stand located between the precipitating vats. This stand was of such height as to permit siphoning the acidified wash water into the vats.

SIPHON FOR DRAINING WHEY AND WASH WATER

A 1-inch hose was used for siphoning the whey and wash water from the precipitating vats and for transferring the wash water from the 20-gallon jar to these vats. A siphon of this size permitted rapid drainage and, at the same time, was not large enough to result in serious curd losses.

SMALL COLORIMETRIC pH SET

This set consisted of two buffer solutions of pH 4.4 and pH 4.8, brom cresol green indicator and three small glass cells. The standard buffer solutions were made up as outlined by Clark (2). The glass cells were taken from a La Motte Hydrogen Ion testing set. A porcelain spot plate could have been substituted for these cells.

DRAINAGE BAGS

Closely woven muslin was made into bags 36 inches long and 18 inches wide. These bags were used for draining excess water from the curd.

BAG HOLDERS

Five-gallon ice cream cans were cut off about 6 inches below the top. Two 1/2-inch holes were drilled through the sides of the can at opposite ends of one of its diameters. These holes were approximately 1 inch from the cut end of the section. Iron rods 14 inches long and 3/8 inch in diameter were passed through the

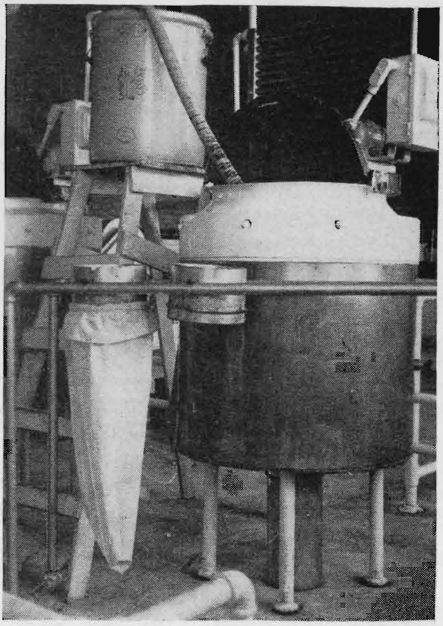

Fig. 1. Equipment used in manufacture of sodium caseinate.

holes of the can sections to hold the rods on the drain rack. In this position the top of the can becomes the bottom of the drainage hoop. The sacks were tied just above the rim normally found on the ice cream can and in this fashion were kept from slipping off during the draining operation. Figure 1 illustrates this set-up.

DRAIN RACK

This piece of equipment was made of 1-inch water pipe and was designed to hold the bags of curd while draining. The plan of the frame is illustrated in fig. 1. It is 56 inches long and 9½ inches wide (inside measurements). The frame stands 31 inches from the floor.

PRECIPITATION, WASHING AND PEPTIZING

The casein was prepared from fresh, high quality, pasteurized (145° F. for 30 minutes) skimmilk. It was precipitated with dilute hydrochloric acid [1 volume concentrated HCl (sp. gr. 1.19) plus 10 volumes of water]. This operation was carried out in vertical 50-gallon insulated vats at 70° F. The dilute acid was siphoned slowly into the skimmilk from the acid jar previously described. The end of the siphon was placed beneath the surface of the skimmilk during the operation. The skimmilk was kept circulating by means of the mechanical agitator until precipitation was completed. This process required 10-15 minutes. The point of complete precipitation (pH 4.6) was determined colorimetrically by using brom cresol green as the indicator. Experimental results show that fresh, pasteurized skimmilk requires 200 cc. of concentrated hydrochloric acid (sp. gr. 1.19) per 100 pounds of skimmilk to precipitate the casein in the manner described above.

As soon as the precipitation was completed the agitator was shut off, and the casein curd was allowed to settle until the whey became clear. This usually required 5-10 minutes. The clear whey was then siphoned off in a manner that did not disturb the soft curd in the bottom of the vat.

The curd was washed twice with 35-40 gallons of acidified wash water (pH 4.8). This wash water was prepared by adding 72-74 cc. of a 1:1[4] solution of hydrochloric acid to 20 gallons of tap water. The pH of this solution was checked colorimetrically, using brom cresol green as the indicator. A volume of this acidified water equal to the volume of the discarded whey was siphoned into the precipitating vat, the contents were well mixed, were allowed to settle 10 minutes or until the water was clear of suspended curd particles and the supernatant liquid siphoned off. The two wash waters removed the bulk of the milk sugar and the milk salts from the curd.

As soon as the second wash water was removed, the wet curd was run into pails and poured into the muslin drainage bags. The curd was drained for several hours. It was stirred occasionally in the bags with a stirring rod to effect a more rapid removal of water. It was found impractical to have the solids content of the finished casein curd above 16 percent since the higher solids curds were difficult to peptize. In addition to this, the peptized sirups were too heavy and viscous to handle at the holding temperature (approximately 35° F.). Most of the casein sirups used in this work had a solids content of 12-16 percent; the greater number were approximately 14 percent. When the solids content of the casein sirups was appreciably below 12 percent it was necessary to use cream with more than 30 percent fat in order to get the desired fat content in the mix. In order to get a solids content of 14 percent in the finished sirup the casein curd in the drainage bags was weighed. From the weight of the curd, the pounds of skimmilk and the average yield of casein (2.6 percent) it was found that 18.5 pounds of curd from each 100 pounds of skimmilk gave approximately 14 percent solids; while a curd weight of 16.2 pounds gave approximately 16 percent solids.

As soon as the curd had drained to the desired weight it was transferred from the bags to 10-gallon cream cans. The cans were never filled more than one-half full, to allow for expansion due to the liberation of carbon dioxide during peptization.

Sodium bicarbonate for peptization was figured on the basis of dry casein. The pounds of dry casein in the wet curd were calculated approximately from the average casein yield (2.6 percent) of the skimmilk. Experimental results obtained showed that 4.75 percent of the weight of the calculated dry casein was the correct weight of sodium bicarbonate to be added to the curd, if the sol were prepared as outlined above. This percentage of sodium bicarbonate, when added to the casein curd, gave a final pH of 6.0-6.1 in the resulting suspension. It

[4] Equal parts of water and HCl (sp. gr. 1.19) by volume.

has been determined experimentally in these laboratories that this pH gave the best results from the standpoint of flavor and acidity in the ice cream.

Sodium bicarbonate for the curd in each 10-gallon can was weighed out accurately and was dissolved in about ½ pint warm water before it was added to the curd. This mixture of curd and sodium bicarbonate was stirred vigorously, and the cans were then placed in hot water (140°-150° F.). The suspension was agitated occasionally until peptization was completed. This usually required about an hour but varied with the solids content, the nature of the curd and the peptization temperature. When complete, the suspension of sodium caseinate had a smooth consistency, a uniform gray-white color and no curd particles. This suspension of sodium caseinate was cooled and held at 32°-38° F. until used.

THE USE OF NON-DESICCATED SODIUM CASEINATE SOLS IN ICE CREAM TO REPLACE DEFINITE AMOUNTS OF SERUM SOLIDS

METHODS OF STANDARDIZING, PROCESSING AND FREEZING

In standardizing these experimental mixes the important thing was to eliminate, as nearly as possible, all variables except the ones under consideration. Since the purpose of this problem was to study the effect of replacing serum solids in the ice cream mix with sodium caseinate sols, the only constituents varied in each run were the skimmilk powder and the casein sirup. The mixes were made from cream, sugar, gelatine, skimmilk powder (spray process), casein sirup and water. The cream, sugar and gelatine were constant in all the mixes of each run. The portion of the serum solids furnished by the skimmilk powder was reduced in 1 percent units from one mix to the next in each run. To insure the serum solids content's being the same in each mix, an amount of casein sol containing a weight of dry casein equivalent to the reduction in weight of moisture-free skimmilk powder was added to the mixes. Since the skimmilk powder was a solid (3 percent water) and the casein sirup was a liquid (85-87 percent water), it was necessary to balance the mixes with water instead of skimmilk which is ordinarily used for this purpose. The method by which the mixes were balanced is illustrated in table 1.

In the 14 percent fat mixes, which used casein, the sugar was increased to 16 percent. The ice cream made from mixes containing 15 percent sugar had a flavor that was flat and lacking in sweetness, due, probably, to replaced lactose and the fact that mixes containing casein seem to require slightly more flavoring and sweetening.

Four series of runs were made as follows:

a. 12% fat, 15% sugar, 0.3% gelatine and 10% serum solids (six mixes per run; casein replaced serum solids 0–5%). (Five runs were made.)

b. 12% fat, 15% sugar, 0.3% gelatine and 8% serum solids (six mixes per run; casein replaced serum solids 0-5%). (Five runs were made.)
c. 14% fat, 16% sugar, 0.3% gelatine and 10% serum solids (six mixes per run; casein replaced serum solids from 0–5%). (Nine runs were made.)
d. 14% fat, 16% sugar, 0.3% gelatine, and 8% serum solids (six mixes per run; casein replaced serum solids from 0–5%). (Six runs were made.)

TABLE 1. SAMPLE MIX CHART.

12 percent Fat Mixes—10 percent Serum Solids.

Ingredients used	Pounds of ingredients used					
	Check	1% sodium caseinate replacement	2% sodium caseinate replacement	3% sodium caseinate replacement	4% sodium caseinate replacement	5% sodium caseinate replacement
30% cream	20.00	20.00	20.00	20.00	20.00	20.00
Sugar	7.50	7.50	7.50	7.50	7.50	7.50
Gelatine	0.15	0.15	0.15	0.15	0.15	0.15
Skimmilk powder	3.90	3.37	2.85	2.33	1.81	1.29
14% sodium Caseinate solution	——	3.57	7.14	10.71	14.28	17.85
Water	18.45	15.41	12.36	9.31	6.26	3.21

The mixes were made in 50-pound batches and were pasteurized in 10-gallon cans at 158° F. for 30 minutes. They were homogenized separately with a Gaulin two-stage homogenizer at the pasteurizing temperature. The homogenization pressures were 2,500 pounds in the first stage and 1,000 pounds in the second stage. The mixes were cooled over a tubular cooler and were held in a cold room at approximately 35° F. for 18 hours.

Forty-five pounds of each mix were frozen in a forty-quart direct-expansion freezer. The ammonia was turned off when the mix had cooled to 24.5° F. as determined by an accurate thermometer. The mix was then whipped to its maximum overrun. This point was determined by making overrun tests at 1-minute intervals with a Mojonnier overrun tester. The ammonia was then turned on, and the ice cream was "frozen back" to 100 percent overrun, at which point a sample was taken for judging.

RESULTS

THE EFFECT OF SODIUM CASEINATE SOLS ON THE WHIPPING QUALITY OF THE ICE CREAM

Tables 2, 3, 4 and 5 present data on the whipping qualities of the four series of runs which were studied. The general trend of the percentage overrun when the refrigerant was shut off was similar in the four series. The initial overrun was increased, as a rule, with each additional percent of sodium caseinate, with the exception of the mix which contained 1 percent sodium caseinate replacement in table 2. There was little difference between the whipping ability of the check and of the

TABLE 2. PERCENTAGE OVERRUN AND TIME TO 100 PERCENT OVERRUN WHEN SODIUM CASEINATE REPLACED VARYING PERCENTAGES OF SERUM SOLIDS.

Mixes containing 14 percent fat and 10 percent serum solids.

	Overrun when ammonia was shut off (temperature ice cream 24.5°F.)						Time for overrun to reach 100% (in minutes)* **						Maximum overrun					
Run no.	Check	1% sodium caseinate repl.	2% sodium caseinate repl.	3% sodium caseinate repl.	4% sodium caseinate repl.	5% sodium caseinate repl.	Check	1% sodium caseinate repl.	2% sodium caseinate repl.	3% sodium caseinate repl.	4% sodium caseinate repl.	5% sodium caseinate repl.	Check	1% sodium caseinate repl.	2% sodium caseinate repl.	3% sodium caseinate repl.	4% sodium caseinate repl.	5% sodium caseinate repl.
1	60	60	72	95	104	115	3.5	4.5	2.5	0.5	−0.5	−1.25	108	113	130	135	over 140	over*** 140
2	60	65	69	95	—	—	2.5	5.5	5.5	1.5	—	—	128	121	113	124	—	—
3	45	52	72	85	—	—	4.5	4.5	3.5	2.5	—	—	126	116	121	124	—	—
4	50	56	68	99	—	—	5.5	5.5	3.5	0.5	—	—	125	117	119	125	—	—
5	76	62	82	77	93	98	2.5	5.5	3.5	3.5	0.5	0.5	130	122	113	128	over 140	128
6	39	51	57	78	101	96	4.5	4.5	5.5	2.5	0.0	0.5	111	115	120	131	over 140	over 140
7	54	55	70	83	87	87	5.5	5.5	1.5	0.5	0.5	0.5	125	121	115	over 140	over 140	over 140
8	51	55	71	91	98	105	4.5	5.5	2.0	2.0	0.5	−1.0	121	120	119	over 140	over 140	over 140
9	60	55	68	88	96	105	6.5	6.0	7.0	0.5	0.5	−1.2	127	128	118	131	138	134
Av.	55.0	56.8	69.9	87.9	96.5	101.0	4.39	5.22	3.83	1.56	0.25	−0.33	122.3	119.2	118.7	130.9	139.7	137.0

*The overrun was taken every minute and the time when the overrun reached 100 percent was estimated to the nearest one-half minute.
**All negative values were obtained by the extrapolation of overrun time curves for each run to 100 percent overrun.
***140 percent was as high as the overrun tester was graduated.

TABLE 3. PERCENTAGE OVERRUN AND TIME TO 100 PERCENT OVERRUN WHEN SODIUM CASEINATE REPLACED VARYING PERCENTAGES OF SERUM SOLIDS.

Mixes containing 14 percent fat and 8 percent serum solids.

	Overrun when ammonia was shut off (temperature ice cream 24.5°F.)						Time for overrun to reach 100% (in minutes)* **						Maximum overrun					
Run no.	Check	1% sodium caseinate repl.	2% sodium caseinate repl.	3% sodium caseinate repl.	4% sodium caseinate repl.	5% sodium caseinate repl.	Check	1% sodium caseinate repl.	2% sodium caseinate repl.	3% sodium caseinate repl.	4% sodium caseinate repl.	5% sodium caseinate repl.	Check	1% sodium caseinate repl.	2% sodium caseinate repl.	3% sodium caseinate repl.	4% sodium caseinate repl.	5% sodium caseinate repl.
1	82	—	94	108	111	113	2.5	—	1.5	−1.2	−1.2	−1.5	127	—	129	132	135	over*** 140
2	78	—	103	115	125	140	3.5	—	−0.4	−1.0	−0.9	X****	107	—	120	over 140	over 140	over 140
3	68	—	105	117	128	140	3.5	—	−0.2	−1.5	−2.2	X****	117	—	122	over 140	over 140	over 140
4	59	—	85	116	125	—	3.5	—	1.5	X****	−1.9	—	114	—	125	125	over 140	over 140
5	58	—	90	131	140	—	3.5	—	1.5	X****	—	—	124	—	126	over 140	over 140	over 140
6	70	79	85	114	—	—	3.5	3.5	1.5	−1.3	—	—	124	125	128	over 140	—	—
Av.	69.2	79.0	93.7	116.8	125.8	131.0	3.33	3.50	0.90	−1.25	−1.55	−1.50	118.8	125.0	125.0	136.2	139.0	over 140.0

*The overrun was taken every minute and the time when the overrun reached 100 percent was estimated to the nearest one-half minute.
**All negative values were obtained by the extrapolation of overrun time curves for each run to 100 percent overrun.
***140 percent was as high as the overrun tester was graduated.
****Impossible to extrapolate these data to 100 percent because of high initial overrun.

TABLE 4. PERCENTAGE OVERRUN AND TIME TO 100 PERCENT OVERRUN WHEN SODIUM CASEINATE REPLACED VARYING PERCENTAGES OF SERUM SOLIDS.

Mixes containing 12 percent fat and 10 percent serum solids.

	Overrun when ammonia was shut off (temperature ice cream 24.5°F.)						Time for overrun to reach 100% (in minutes)* **						Maximum overrun					
Run no.	Check	1% sodium caseinate repl.	2% sodium caseinate repl.	3% sodium caseinate repl.	4% sodium caseinate repl.	5% sodium caseinate repl.	Check	1% sodium caseinate repl.	2% sodium caseinate repl.	3% sodium caseinate repl.	4% sodium caseinate repl.	5% sodium caseinate repl.	Check	1% sodium caseinate repl.	2% sodium caseinate repl.	3% sodium caseinate repl.	4% sodium caseinate repl.	5% sodium caseinate repl.
1	52	65	74	96	103	118	4.0	3.5	3.0	0.5	−0.2	−1.4	108	124	over 140	130	over 140	over*** 140
2	67	71	96	106	116	—	3.0	3.5	1.0	−0.6	−0.7	—	111	110	115	128	over 140	—
3	50	67	76	100	118	128	4.5	3.0	2.5	0.0	−0.85	−1.5	105	120	116	over 140	over 140	over 140
4	49	60	99	104	115	130	6.5	5.5	0.5	−0.6	−1.6	−1.9	106	105	123	over 140	over 140	over 140
5	46	60	75	99	109	125	5.0	5.0	1.5	0.5	−0.5	−2.0	113	111	120	130	over 140	over 140
Av.	52.8	64.6	84.0	101.0	112.2	125.3	4.60	4.10	1.70	−0.04	−0.77	−1.70	108.6	114.0	122.8	133.6	over 140.0	over 140.0

*The overrun was taken every minute and the time when the overrun reached 100 percent was estimated to the nearest one-half minute.
**All negative values were obtained by the extrapolation of overrun time curves for each run to 100 percent overrun.
***140 percent was as high as the overrun tester was graduated.

TABLE 5. PERCENTAGE OVERRUN AND TIME TO 100 PERCENT OVERRUN WHEN SODIUM CASEINATE REPLACED VARYING PERCENTAGES OF SERUM SOLIDS.

Mixes containing 12 percent fat and 8 percent serum solids.

	Overrun when ammonia was shut off (temperature ice cream 24.5°F.)						Time for overrun to reach 100% (in minutes)* **						Maximum overrun					
Run no.	Check	1% sodium caesinate repl.	2% sodium caseinate repl.	3% sodium caseinate repl.	4% sodium caseinate repl.	5% sodium caseinate repl.	Check	1% sodium caseinate repl.	2% sodium caseinate repl.	3% sodium caseinate repl.	4% sodium caseinate repl.	5% sodium caseinate repl.	Check	1% sodium caseinate repl.	2% sodium caseinate repl.	3% sodium caseinate repl.	4% sodium caseinate repl.	5% sodium caseinate repl.
1	67	78	84	108	118	140	did not reach	3.5	1.5	−1.0	−1.7	X****	93	117	over 140	over 140	over 140	over*** 140
2	58	75	91	112	120	122	100%	4.5	0.5	−1.0	−1.4	−2.0	94	105	115	136	over 140	over 140
3	55	63	89	105	117	128	"	6.5	1.5	−0.8	−1.2	−1.7	76	101	123	134	over 140	over 140
4	58	63	78	96	106	120	"	did not reach 100%	1.5	0.5	−0.8	−1.2	88	98	123	130	over 140	over 140
5	60	58	79	98	112	119	"	"	4.5	1.5	−1.1	−1.7	92	93	108	120	129	over 140
Av.	59.6	67.4	84.2	103.8	114.6	125.8	—	4.83	1.90	−0.16	−1.24	−1.65	88.6	102.8	121.8	132.0	137.8	140.0

*The overrun was taken every minute and the time when the overrun reached 100 percent was estimated to the nearest one-half minute.
**All negative values were obtained by the extrapolation of overrun time curves for each run to 100 percent overrun.
***140 percent was as high as the overrun tester was graduated.
***Impossible to extrapolate these data to 100 percent because of high initial overrun.

1 percent sodium caseinate samples in table 2. This can be attributed to the fact that the latter mix was balanced with skimmilk, while all of the mixes containing sodium caseinate were balanced with water. The use of skimmilk necessitated a lower percentage of skimmilk powder in the check mix, a fact which explains the better overrun obtained, since skimmilk powder is an overrun deterrent. The mixes containing high percentages of sodium caseinate, in tables 3, 4 and 5, had overrun values considerably in excess of 100 percent by the time the refrigerant was shut off and the whipping was begun. These mixes, therefore, would have no place in the ice cream plant because the ice cream is taken from the freezer when the overrun reaches approximately 100 percent. ''Freezing back'' is not practical, and drawing the ice cream at too high a temperature introduces serious body defects. Values in table 2 do not show this difficulty because of the high percentages of fat and of serum solids used which act as overrun deterrents. Check samples in tables 2 and 3 show improved whipping qualities over the check samples in tables 4 and 5, because skimmilk was used to balance the latter.

Sodium caseinate reduced time necessary for the overrun to reach 100 percent. The higher sodium caseinate percentages gave negative values because the percentage overrun was higher than 100 before whipping was begun. These negative values were obtained by extrapolating the overrun time curves for each trial to 100 percent overrun and are, therefore, only approximate values. In those cases in which the initial overrun was too high, the time at 100 percent overrun could not be obtained by extrapolation with any degree of precision; for that reason no values are presented for these mixes.

Maximum overrun generally was increased with each additional percent of sodium caseinate. The maximum overrun values presented for the mixes containing the higher percentages of sodium caseinate are not precise because the maximum value that could be read with the overrun tester used was 140 percent. Also there was no suitable means of estimating the true values for these mixes with the time available for this determination.

CHARACTER OF THE FINISHED ICE CREAM

The samples of ice cream from each lot of mixes were held at -10° F. for 24 hours before they were judged. All samples were judged for flavor and for body and texture by five members of the dairy industry faculty. Averages of the scores of these judges are the values presented in accompanying tables. Occasionally melting tests were made on all of the samples from one of the runs. In all instances the melting tests for the same series checked each other.

FLAVOR SCORES

The flavor scores are presented in table 6, 7, 8 and 9. These scores increased, as the percentage of sodium caseinate replacement increased, to approximately 3 percent in table 6 and 4 percent in tables 7, 8 and 9. With replacement above these amounts the flavor scores dropped.

TABLE 6. THE AVERAGES OF THE FLAVOR SCORES (BY FIVE JUDGES) OF ICE CREAM IN WHICH SODIUM CASEINATE REPLACED VARYING PERCENTAGES OF SERUM SOLIDS.

Mixes containing 14 percent fat and 10 percent serum solids.

Run number	Check	1% sodium caseinate replacement	2% sodium caseinate replacement	3% sodium caseinate replacement	4% sodium caseinate replacement	5% sodium caseinate replacement
1	44.75	44.87	45.00	45.50	45.50	45.50
2	44.50	44.00	45.25	45.00	——	——
3	45.25	45.25	45.25	45.25	——	——
4	45.00	45.00	45.00	45.00	——	——
5	44.00	44.25	44.50	44.12	44.00	43.87
6	44.75	44.90	44.80	45.16	44.80	44.60
7	44.37	45.00	45.00	44.75	44.87	45.00
8	44.00	45.00	44.75	45.00	45.00	45.12
9	43.50	45.50	45.10	45.50	45.37	45.56
Av.	44.457	44.863	44.961	45.031	44.923	44.941

TABLE 7. THE AVERAGES OF THE FLAVOR SCORES (BY FIVE JUDGES) OF ICE CREAM IN WHICH SODIUM CASEINATE REPLACED VARYING PERCENTAGES OF SERUM SOLIDS.

Mixes containing 14 percent fat and 8 percent serum solids.

Run number	Check	1% sodium caseinate replacement	2% sodium caseinate replacement	3% sodium caseinate replacement	4% sodium caseinate replacement	5% sodium caseinate replacement
1	42.87	——	44.37	44.68	44.87	44.75
2	43.75	——	44.06	44.37	44.37	44.37
3	43.50	——	44.12	44.25	44.50	——
4	43.83	——	44.21	44.58	44.66	——
5	43.93	——	44.37	44.62	44.43	——
6	43.87	44.25	44.37	44.50	——	——
Av.	43.625	44.250	44.250	44.500	44.560	44.566

TABLE 8. THE AVERAGES OF THE FLAVOR SCORES (BY FIVE JUDGES) OF ICE CREAM IN WHICH SODIUM CASEINATE REPLACED VARYING PERCENTAGES OF SERUM SOLIDS.

Mixes containing 12 percent fat and 10 percent serum solids.

Run number	Check	1% sodium caseinate replacement	2% sodium caseinate replacement	3% sodium caseinate replacement	4% sodium caseinate replacement	5% sodium caseinate replacement
1	44.88	44.50	44.75	45.00	45.00	45.00
2	44.00	44.75	44.75	45.00	45.50	——
3	44.75	44.75	44.25	44.50	45.00	45.25
4	43.50	43.97	44.50	45.00	45.50	44.00
5	44.00	44.50	44.50	44.50	44.50	44.00
Av.	44.226	44.494	44.550	44.800	45.100	44.562

TABLE 9. THE AVERAGES OF THE FLAVOR SCORES (BY FIVE JUDGES) OF ICE CREAM IN WHICH SODIUM CASEINATE REPLACED VARYING PERCENTAGES OF SERUM SOLIDS.

Mixes containing 12 percent fat and 8 percent serum solids.

Run number	Check	1% sodium caseinate replacement	2% sodium caseinate replacement	3% sodium caseinate replacement	4% sodium caseinate replacement	5% sodium caseinate replacement
1	43.50	43.90	44.50	44.68	45.00	44.78
2	44.00	44.00	44.33	44.50	45.00	45.00
3	43.75	43.75	44.50	44.25	44.75	44.25
4	43.00	44.25	44.50	44.50	44.50	44.50
5	43.33	44.00	44.12	44.75	45.00	45.50
Av.	43.516	43.980	44.390	44.536	44.850	44.806

BODY AND TEXTURE SCORES

Tables 10 to 13 present the body and texture scores for the four series of runs. These scores increased, as the percentage of sodium caseinate replacement increased, to between 2 and 3 percent in table 10, 4-5 percent in table 11, 4 percent in table 12 and 5 percent in table 13.

A COMPARISON OF FLAVOR AND OF BODY AND TEXTURE SCORES AMONG THE "BEST" SAMPLES OF THE FOUR SERIES

Table 14 compares the flavor of the "best" mixes of each of the four series studied. The two 10 percent serum solids mixes gave the highest flavor scores, while the check mix scored the lowest. Although the difference between the highest and lowest flavor scores was only ½ point it was considered important since it represented definite improvement in flavor.

Table 15 compares the body and texture scores for these "best" mixes of each of the four series. The 14 percent fat, 10 percent serum solids mix, containing 3 percent sodium caseinate replacement, was the outstanding mix with regard to body and

TABLE 10. THE AVERAGES OF THE BODY AND TEXTURE SCORES (BY FIVE JUDGES) OF ICE CREAM IN WHICH SODIUM CASEINATE REPLACED VARYING PERCENTAGES OF SERUM SOLIDS.

Mixes containing 14 percent fat and 10 percent serum solids.

Run number	Check	1% sodium caseinate replacement	2% sodium caseinate replacement	3% sodium caseinate replacement	4% sodium caseinate replacement	5% sodium caseinate replacement
1	24.12	24.12	24.25	24.50	24.37	24.25
2	24.00	24.00	24.50	24.30	——	——
3	23.91	24.00	24.33	24.22	——	——
4	23.87	24.00	24.25	24.50	——	——
5	23.43	24.00	24.00	24.30	23.95	23.85
6	23.66	24.16	24.50	24.33	24.04	23.91
7	23.37	23.75	24.43	24.31	24.18	24.06
8	23.37	23.81	24.43	24.12	24.18	24.06
9	23.47	23.93	24.19	24.25	24.00	23.83
Av.	23.688	23.974	24.320	24.314	24.120	23.993

TABLE 11. THE AVERAGES OF THE BODY AND TEXTURE SCORES (BY FIVE JUDGES) OF ICE CREAM IN WHICH SODIUM CASEINATE REPLACED VARYING PERCENTAGES OF SERUM SOLIDS.

Mixes containing 14 percent fat and 8 percent serum solids.

Run number	Check	1% sodium caseinate replacement	2% sodium caseinate replacement	3% sodium caseinate replacement	4% sodium caseinate replacement	5% sodium caseinate replacement
1	23.25	——	23.62	24.06	24.27	24.25
2	23.50	——	23.81	24.21	24.37	24.12
3	23.40	——	23.88	24.09	24.25	——
4	23.28	——	23.59	23.95	24.00	——
5	23.37	——	23.63	23.93	24.06	——
6	23.37	23.66	23.90	24.12	——	——
Av.	23.361	23.660	23.738	24.060	24.190	24.185

TABLE 12. THE AVERAGES OF THE BODY AND TEXTURE SCORES (BY FIVE JUDGES) OF ICE CREAM IN WHICH SODIUM CASEINATE REPLACED VARYING PERCENTAGES OF SERUM SOLIDS.

Mixes containing 12 percent fat and 10 percent serum solids.

Run number	Check	1% sodium caseinate replacement	2% sodium caseinate replacement	3% sodium caseinate replacement	4% sodium caseinate replacement	5% sodium caseinate replacement
1	23.33	23.60	24.00	24.33	24.50	24.22
2	23.25	23.87	23.75	24.25	24.50	——
3	23.40	23.60	24.10	24.30	24.50	24.25
4	23.50	23.78	23.96	24.17	24.30	24.17
5	23.66	23.70	23.97	24.25	24.50	24.12
Av.	23.428	23.710	23.956	24.260	24.460	24.190

TABLE 13. THE AVERAGES OF THE BODY AND TEXTURE SCORES (BY FIVE JUDGES) OF ICE CREAM IN WHICH SODIUM CASEINATE REPLACED VARYING PERCENTAGES OF SERUM SOLIDS.

Mixes containing 12 percent fat and 8 percent serum solids.

Run number	Check	1% sodium caseinate replacement	2% sodium caseinate replacement	3% sodium caseinate replacement	4% sodium caseinate replacement	5% sodium caseinate replacement
1	23.00	23.50	23.88	24.00	24.25	24.38
2	23.12	23.43	23.66	23.93	24.17	24.33
3	23.06	23.56	23.75	23.97	24.12	24.25
4	22.98	23.41	23.66	24.08	24.16	24.28
5	23.12	23.50	23.75	23.97	24.17	24.30
Av.	23.056	23.480	23.740	23.990	24.174	24.308

texture and received an average score of 24.44 out of a possible 25.0 points. The mixes containing 12 percent fat, 10 percent serum solids, 3 percent sodium caseinate replacement and 14 percent fat, 8 percent serum solids, 2 percent sodium caseinate replacement had approximately the same average scores and were in second place. The check mix was placed last, although its score was within 0.03 point of that received by the 12 percent

TABLE 14. AVERAGE FLAVOR SCORES OF THE BEST MIXES OF EACH OF THE FOUR SERIES STUDIED.

Run number	Check 14% fat 10% M.S.N.F.	14% fat 10% M.S.N.F. 3% sodium caseinate replacement	14% fat 8% M.S.N.F. 2% sodium caseinate replacement	12% fat 10% M.S.N.F. 3% sodium caseinate replacement	12% fat 8% M.S.N.F. 2% sodium caseinate replacement
1	44.50	44.75	45.00	44.62	44.25
2	44.00	44.75	44.00	44.75	44.00
3	44.25	44.66	44.50	44.60	44.50
4	——	——	——	——	——
5	44.05	44.55	44.55	44.80	44.75
Av.	44.200	44.677	44.512	44.692	44.375

TABLE 15. AVERAGE BODY AND TEXTURE SCORES OF THE BEST MIXES OF EACH OF THE FOUR SERIES STUDIED.

Run number	Check 14% fat 10% M.S.N.F.	14% fat 10% M.S.N.F. 3% sodium caseinate replacement	14% fat 8% M.S.N.F. 2% sodium caseinate replacement	12% fat 10% M.S.N.F. 3% sodium caseinate replacement	12% fat 8% M.S.N.F. 2% sodium caseinate replacement
1	23.87	24.50	24.00	24.18	23.93
2	23.50	24.41	23.91	24.25	23.75
3	23.93	24.37	24.12	24.18	23.75
4	23.87	24.50	24.50	24.25	23.93
5	24.00	24.45	24.30	24.05	23.95
Av.	23.834	24.446	24.166	24.182	23.862

fat, 8 percent serum solids, 2 per cent sodium caseinate replacement sample. The two mixes containing 8 percent serum solids had only 2 percent sodium caseinate replacement in comparison with 3 percent sodium caseinate replacement in the 10 percent serum solid mixes because the whipping qualities of these mixes prevented using a higher percentage.

MELTING QUALITY

Figure 2 presents a typical melting test. The samples are: (from left to right) the check, the sample with 3 percent sodium caseinate replacement and the sample with 5 percent sodium caseinate replacement.

The top photograph was taken immediately after removing the samples from the hardening room; the center photograph presents the same samples after 30 minutes at room temperature and the bottom photograph presents these samples after 90 minutes at room temperature.

The check sample melted down slowly and left a frothy mass which "wheyed off" slightly. The sample had just begun to drip from the plate at the time the last picture was taken. The sodium caseinate samples, on the contrary, melted down more rapidly with a characteristic sheen. The melted portion had the appearance of the original mix and showed no signs of "wheying off;" neither did it leave a frothy appearance in the unmelted portion. The casein samples were criticized for the formation of large air bubbles on the surface of the melted portion during the latter part of the melting period.

CONSUMER PREFERENCE

The judges were consistent and uniform in their scoring of samples throughout the duration of the experiment. It was felt necessary, however, to have disinterested persons judge the samples in order to determine whether the opinions of the judges were coincident with consumer preference. Table 16 is a summary of the data obtained on three samples judged by one of the Ames women's clubs. It was felt that these results would

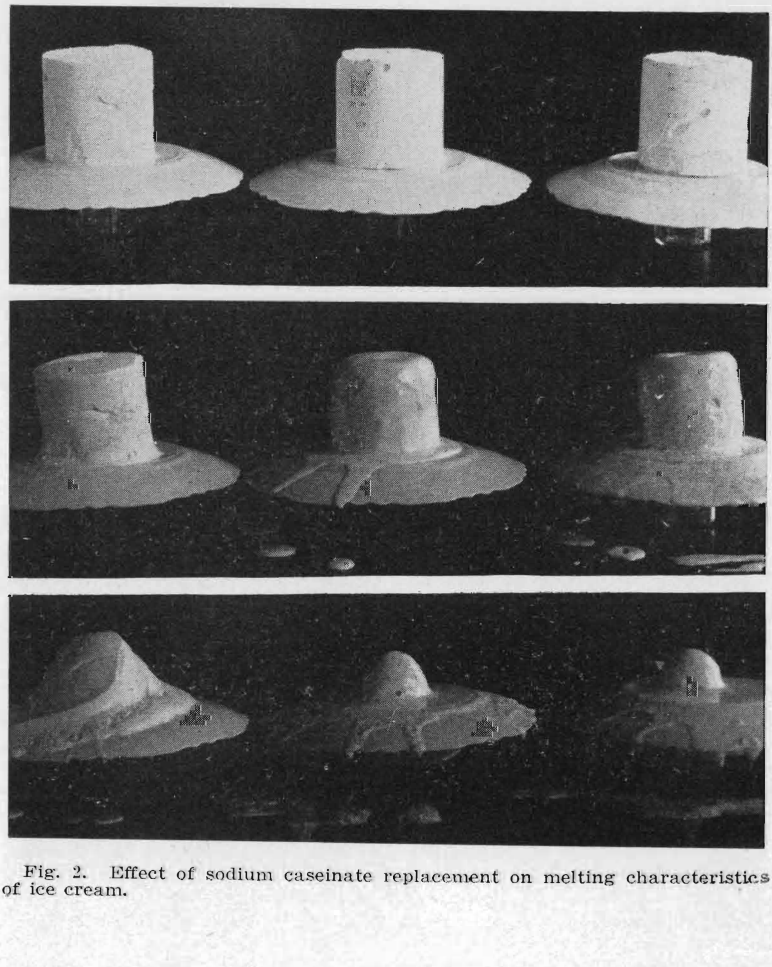

Fig. 2. Effect of sodium caseinate replacement on melting characteristics of ice cream.

be typical of the tastes of women who had had considerable experience in buying food products.

This set of samples consisted of a check sample containing no sodium caseinate, a sample containing 3 percent sodium caseinate and a sample containing 5 percent sodium caseinate.

Eighty-eight women judged the samples and gave their placings in the order of preference. The 5 percent sodium caseinate sample was given first place by a wide margin. The 3 percent sodium caseinate sample placed second and the check sample placed third. This placing was contrary to the expectation of the judges who had considered the 5 percent sample to be gummy in body and who had expected this defect to be more severely criticized by the consumers than by themselves. Forty-six of these club women placed the 5 percent sodium caseinate sample first, and 27 placed the 3 percent sodium caseinate sample first, making a total of 73 of the 88 women who preferred the ice cream with added sodium caseinate to the regular ice cream.

TABLE 16. PLACEMENTS OF THREE SAMPLES OF ICE CREAM BY 88 MEMBERS OF A WOMAN'S CLUB.

	Number of times placed 1st	Number of times placed 2nd	Number of times placed 3rd	Total points*
5% sodium caseinate replacement	46	26	16	146
3% sodium caseinate replacement	27	35	26	175
Check	15	27	46	207

*The total points in the last column were the sums of the values obtained by multiplying the number of the placing by the number of samples in that placing.

DISCUSSION OF RESULTS

Figures 3, 4, 5 and 6 present the overrun curves for the four series of mixes. Graph 1, in each of these figures, shows the effect of the percentage of sodium caseinate replacement in the mix on the percentage overrun when the refrigerant was shut off. In fig. 3, 1 percent sodium caseinate had no effect on the initial overrun, whereas 2 percent increased it 12 percent. The maximum rate of increase was reached between 2 and 3 percent sodium caseinate. Four and 5 percent of sodium caseinate continued to increase the initial overrun but at a slower rate. Graph 1, fig. 4, has the same type curve as graph 1, fig. 3, although the entire curve is shifted to the right and shows a higher initial overrun for all the mixes. This is because of the smaller amount of skimmilk powder required in these lower solids mixes. The last three mixes in this series are not practical unless facilities for more rapid freezing than were used in

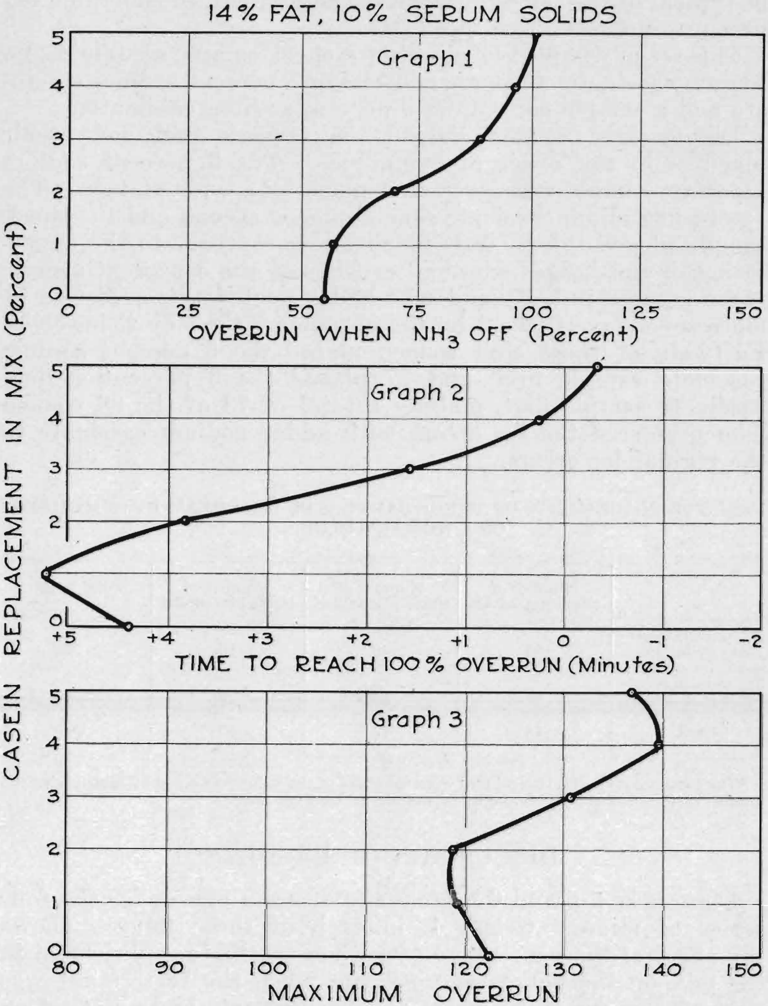

Fig. 3. Effect of sodium caseinate replacement on ice cream overrun.

this work are available. This is because the overrun was higher than 100 percent before the ice cream was frozen to the proper temperature or consistency. Graphs 1 in figs. 5 and 6, are almost identical, the chief difference being a slightly higher overrun with the check mix in fig. 6.

Graph 2, in each of figs. 3, 4, 5 and 6, shows the effect of sodium caseinate replacement on the time of whipping necessary to bring the overrun to 100 percent. The check mix, fig. 3, reached 100 percent overrun in less time than the 1 percent

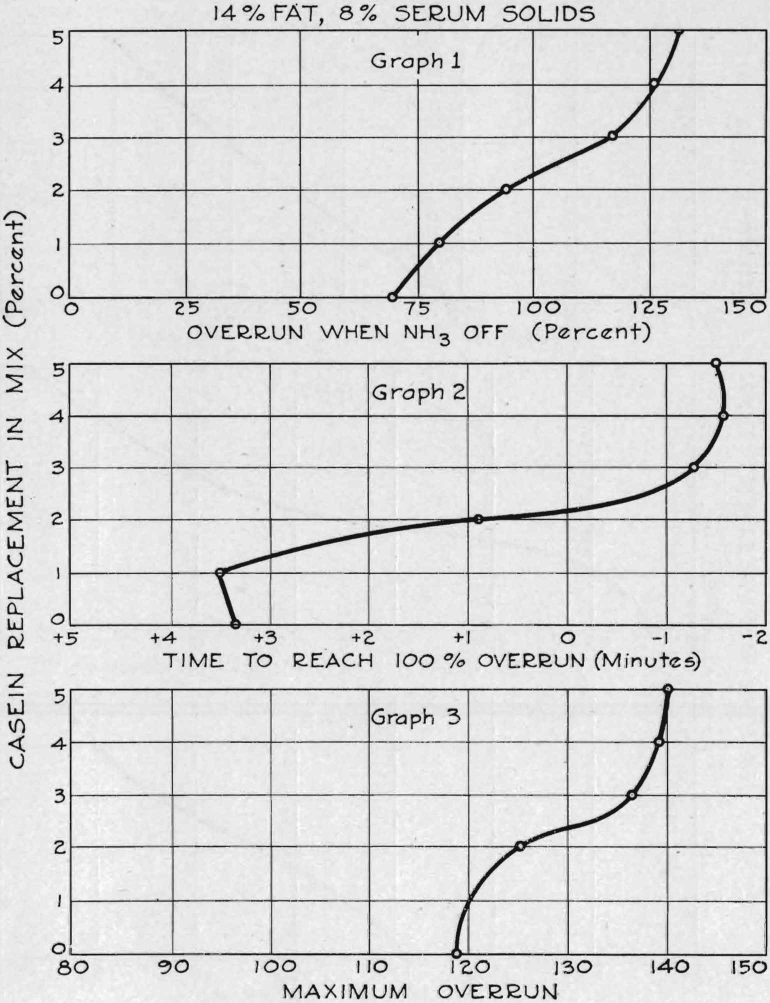

Fig. 4. Effect of sodium caseinate replacement on ice cream overrun.

sodium caseinate replacement mix, because the check was balanced with skimmilk while the sodium caseinate mixes were balanced with water (as was explained under methods of standardization). The 2 percent mix, however, overcame this handicap, and each succeeding increase in sodium caseinate reduced the whipping time. The overrun of the 5 percent sodium caseinate mixes was higher than 100 percent when the ammonia was shut off, so that the whipping time has a negative

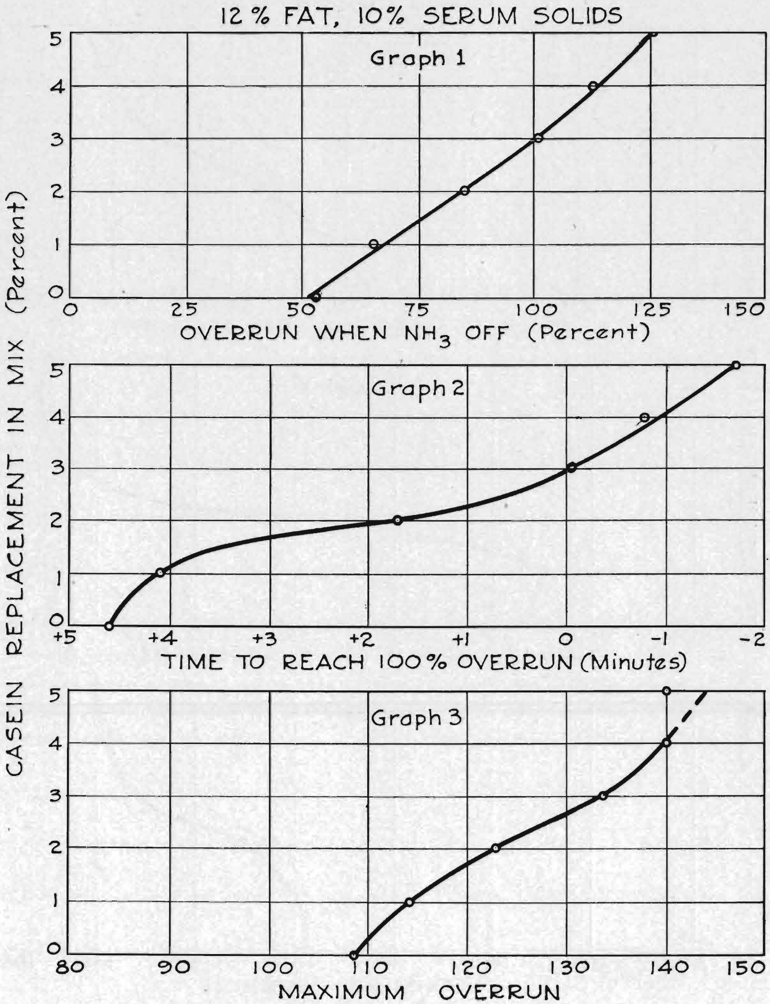

Fig 5. Effect of sodium caseinate replacement on ice cream overrun.

value which was estimated by extrapolation of the overrun time curves for those mixes.

The types of graphs 2, in figs. 3 and 4, are very similar. In fig. 4, the mixes required a much shorter time to whip to 100 percent overrun than did those in fig. 3. The check mix in this series was likewise balanced with skimmilk and for that reason whipped more rapidly than did the 1 percent mix. The 3, 4 and 5 percent mixes had negative values, since the initial overrun was higher than 100 percent when the refrigerant was shut off.

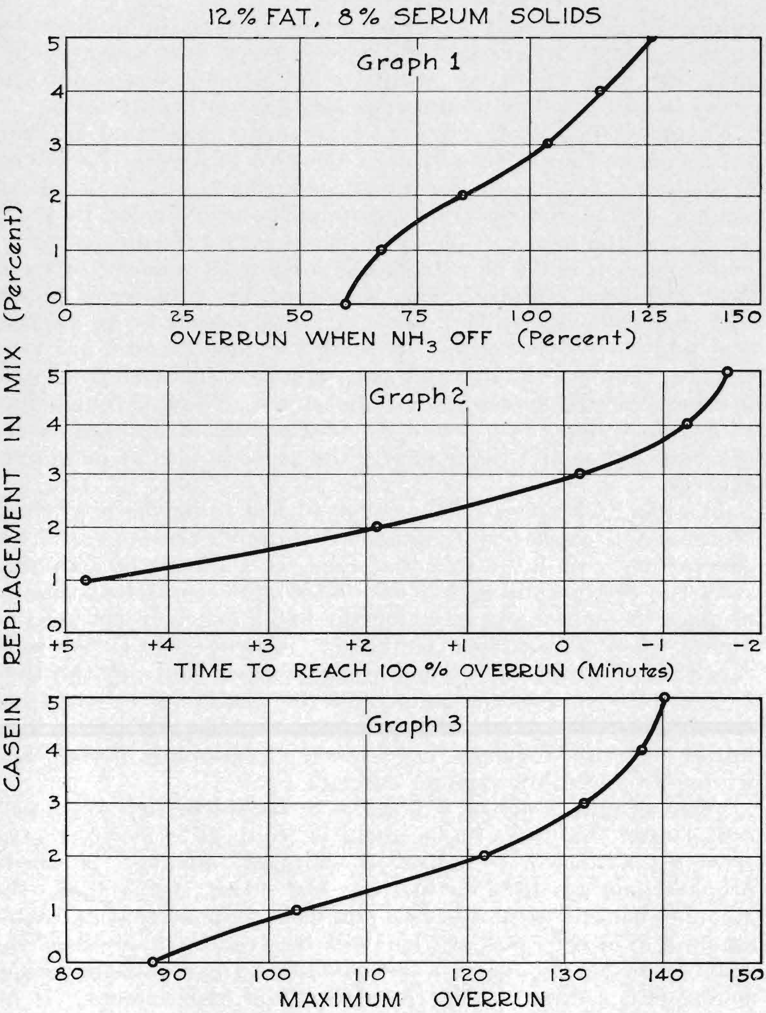

Fig. 6. Effect of sodium caseinate replacement on ice cream overrun.

The reason for the use of skimmilk in the standardization of the 10 percent serum solids mixes was to obtain results comparable with the standard mix manufactured in the college plant. This mix contains 14 percent fat and 10 percent serum solids.

Graphs 2, in figs. 5 and 6, are somewhat smoother than those in figs. 3 and 4. In fig. 5 the check mix was balanced with water and required a greater length of time to reach 100 percent overrun than did the 1 percent sodium caseinate mix. The values for the 3, 4 and 5 percent mixes were again obtained by extrapolation. In graph 2, fig. 6, the check mix had no value since the mix would not whip to 100 percent overrun. The curve is quite similar in all other respects to that in fig. 5.

Graphs 3, figs. 3, 4, 5 and 6, present the maximum overrun values of the four series of runs. The two 14 percent fat mixes, figs. 3 and 4, again show the effects of the skimmilk in the check sample, although this is not particularly pronounced in the 8 percent solids mix. In fig. 3 the maximum overrun decreased with 1 percent and 2 percent sodium caseinate replacements and then increased rapidly. The values in fig. 4 increase slowly with replacements up to 1 percent, rapidly from 1.5 to 3.5 percent and slowly thereafter. Graphs 3 of figs. 5 and 6 are very similar; they are smooth and show a steady increase from zero to 5 percent sodium caseinate replacement. The last four points of graphs 3, figs. 3, 4, 5 and 6, yield curves of approximately the same shape and cover nearly the same ranges of maximum overrun.

The ideal whipping mix was considered to be the one which requires approximately 1 minute of whipping time to reach 100 percent overrun, i.e., a mix that requires 1 minute of whipping after the refrigerant is shut off. This allows sufficient time to prepare the containers in which the batch of ice cream is to be placed when drawn from the freezer. The overrun curves indicate that the overrun when the ammonia is shut off, the time to reach 100 percent overrun and the maximum overrun are closely related. A mix that whipped rapidly and had a high initial overrun required only a short whipping period and whipped to a high maximum overrun.

From graphs 2, figs. 3, 4, 5 and 6, it is evident that $1\frac{1}{2}$-2 percent sodium caseinate replacement is required to justify its use from a standpoint of improved whipping quality. If casein preparations are used to increase the serum solids above the amounts usually employed in a mix, it is assumed that a greater amount of casein preparation will be needed to produce the same effect on the overrun as was obtained by replacing serum solids with sodium caseinate sol in these experiments. If an amount of a casein preparation equivalent to or in excess of $1\frac{1}{2}$ percent is employed in addition to the regular amount of serum solids, a heavy gummy body and texture should be produced; then, it would appear that the body and texture improvement resulting from added commercial milk proteins might not justify their cost. Such preparations as have been examined here have given sols of greater alkalinity than pH 6.0 to 6.2 in concentrations comparable with those employed in this work. It seems plausible to expect such amounts of these products as would give improvement in whipping qualities might tend to produce flavor defects.

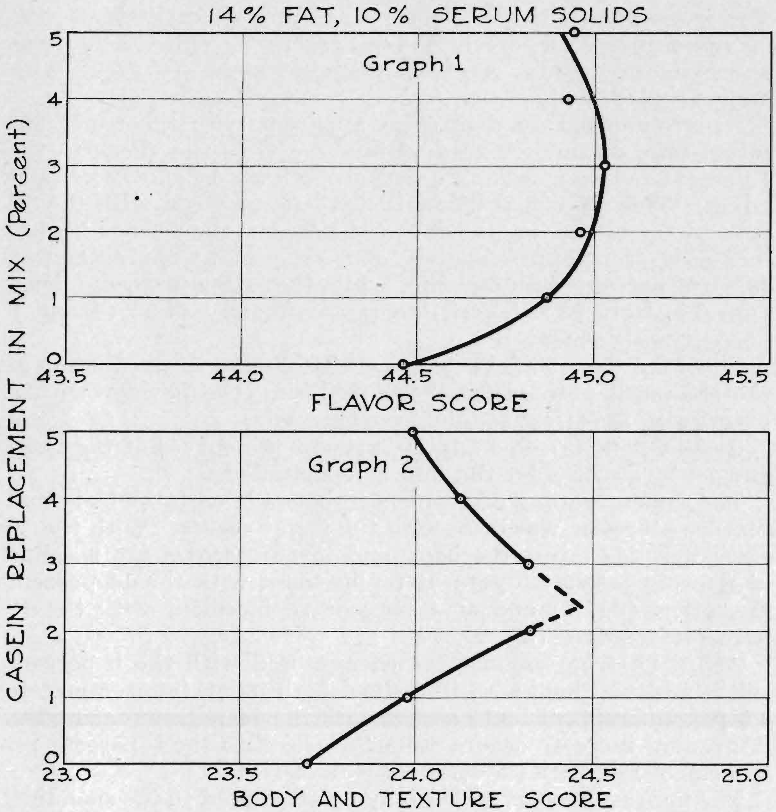

Fig. 7. Effect of sodium caseinate replacement on flavor and body and texture scores.

Graphs 1, figs. 7, 8, 9 and 10, present the flavor score curves of the four series of mixes. The flavor differences among the five mixes in each of the four series range from approximately 0.5 of a point in fig. 7 to 1.5 points in fig. 10. Only pure vanilla was employed as a flavor, and the same extract was used in all the mixes of each run. An improvement of ½ point on the flavor score of the ice cream (above 44) indicates marked improvement and a high quality product.

The flavor score curves can be grouped roughly into a 10 percent serum solids class (figs. 7 and 9) and an 8 percent serum solids (figs. 8 and 10). In the 10 percent solids group the scores for the 14 percent fat mixes increased from approximately 44.45 in the check to approximately 45 with the 3 percent sodium caseinate replacement mix and then slowly decreased. The 12 percent fat mixes in this solids class showed greater variation.

The low score (with the check) was approximately 44.21; the maximum point (4 percent sodium caseinate replacement) was approximately 45.1. A sharp decrease seems to occur with higher replacements.

No pronounced maxima seem apparent with the 8 percent serum solid mixes. A gradual increase from the check to the 4 percent replacement mix occurs in both the 14 and 12 percent mixes. This beneficial effect is more pronounced with the 12 percent fat mixes than with the 14 percent, the former having increased from approximately 43.5 (check) to approximately 44.85 (4 percent replacement), while the latter increased from approximately 43.6 (check) to approximately 44.55 (4 and 5 percent replacements).

These increases in flavor score are attributed to a reduction of the skimmilk powder flavor by replacing the powder with a practically flavorless sodium caseinate sol.

Graphs 2, figs. 7, 8, 9 and 10, present the curves of the body and texture scores for the four series studied.

The same grouping of graphs can be made with the body and texture scores as was done with the flavor scores. With the 10 percent solids mixes the body and texture scores are maxima at approximately 2.5 percent replacement with the 14 percent fat mixes (fig. 7) and at 4 percent replacement with the 12 percent fat mixes (fig. 9).

Again no true maxima are encountered with the 8 percent solids mixes although an ill-defined high point (approximately 4.5 percent replacement) occurs with the 14 percent fat mixes. A gradual increase occurs from the check to the 5 percent replacement mix with the 12 percent fat series.

The improvement in scores may be attributed to the smoother texture resulting from the progressively increased amounts of sodium caseinate sols. The decreases that occur after the maxima were caused by a heaviness or gumminess of the body with the higher sodium caseinate replacements. As would be expected, these maxima occur at lower percentages of replacement with the 10 percent solids mixes than with the 8 percent, since heaviness is a function of total serum solids content.

In the preceding comparisons it was noted that the check samples (tables 2 and 3, graphs 2, figs. 3 and 4) were standardized with skimmilk instead of water. This was done in order that comparisons of the sodium caseinate samples with the regular mix (14 percent fat, 10 percent serum solids) manufactured in the college plant could be obtained. It will be noted that in the comparisons presented these checks scored 43.6 in flavor and 23.46 in body and texture (fig. 8) for the 14 percent fat, 8 percent serum solids mixes, while the scores for the 14 percent fat, 10 percent serum solids mixes were, respectively, 44.35 and

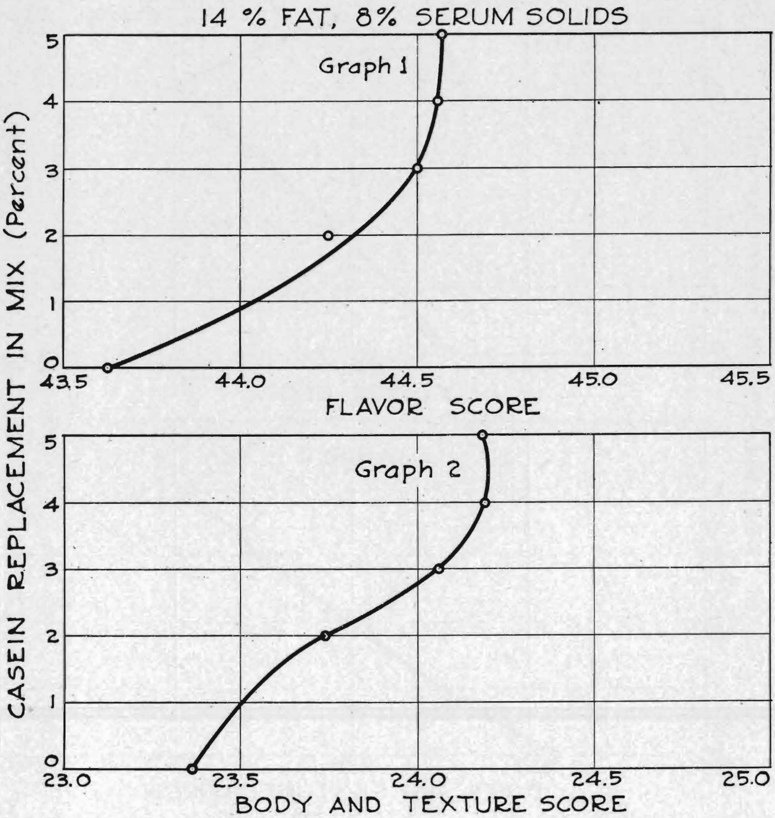

Fig. 8. Effect of sodium caseinate replacement on flavor and body and texture scores.

23.69 (fig. 7). These figures may be somewhat misleading in that in a class of normal commercial ice creams these samples would have scored at least 44 in flavor and at least 24 in body and texture. The classes were unknown to the judges, a fact which had the effect of lowering the scores of the check samples, because they were judged in comparison with samples that had somewhat finer flavors and somewhat better bodies and textures than are found generally in the trade. Had the checks been used as key samples and given, arbitrarily, scores of 44 and 24, respectively, in flavor and body and texture, the relative scores of the samples containing sodium caseinate would have been higher than those recorded in the tables (with the exception of the body and texture scores of the 14 percent fat, 10 percent serum solids samples).

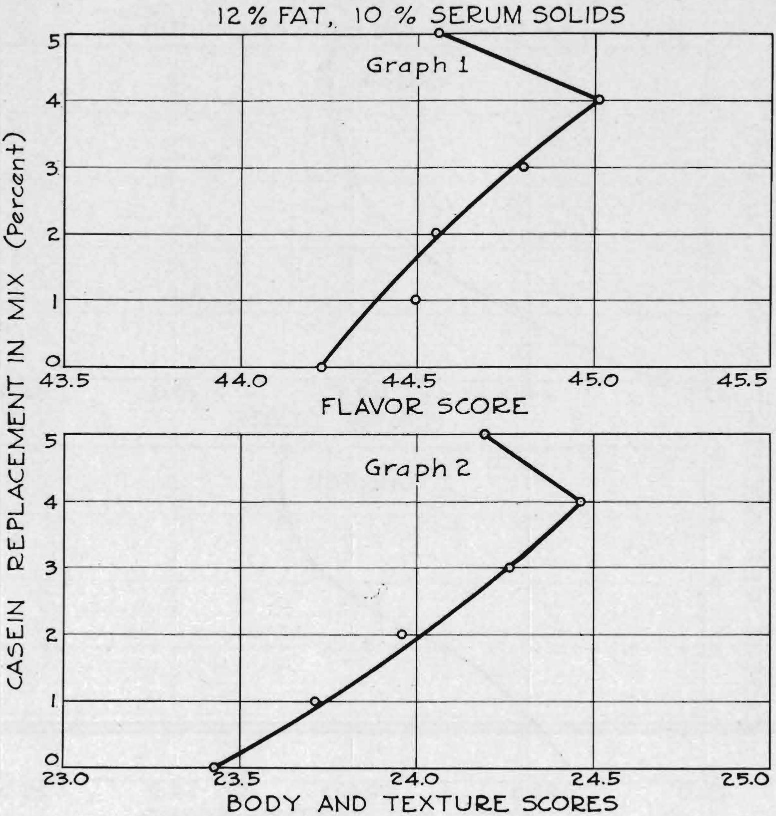

Fig. 9. Effect of sodium caseinate replacement on flavor and body and texture scores.

Tables 14 and 15 (see results) compared the "best" mixes from each of the four series, as regards flavor, and body and texture. The best mix from each series was selected on the basis of flavor, body and texture and whipping quality. It is obvious that, regardless of the value of the flavor and the body and texture scores, no samples that had overrun qualities that were not compatible with commercial plant practice could be chosen. In the selection of the mixes those were chosen which had the best flavor and body and texture scores, with whipping times of from 1 to 2 minutes.

Of the samples selected as the best, it will be evident that the whipping qualities will have been more or less fixed in their selection so that they would need to be compared only as regards flavor and body and texture. A study of tables 14 and 15 shows that of the 14 percent fat mixes, the 10 percent serum

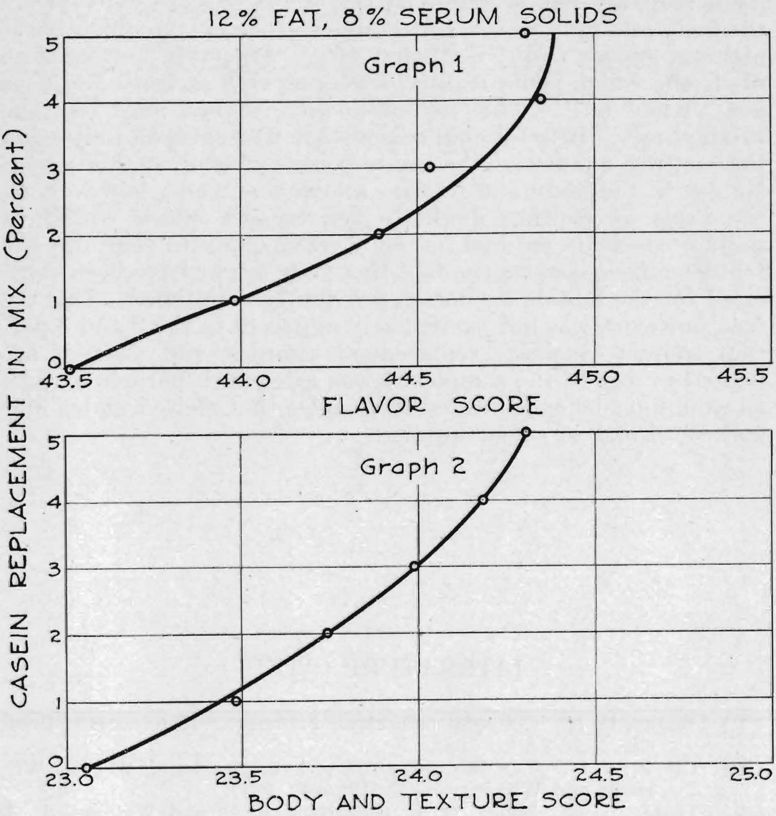

Fig. 10. Effect of sodium caseinate replacement on flavor and body and texture scores.

solids, 3 percent sodium caseinate sample was slightly higher in flavor score than the companion 14 percent fat, 8 percent serum solids sample; as regards body and texture, however, the former sample was 0.28 of a point higher. Similarly, the 12 percent fat, 10 percent serum solids sample proved to be better than the 12 percent fat, 8 percent serum solids sample. The flavor score of the former was 0.31 of a point higher and its body and texture score was 0.32 of a point higher than the 12 percent fat, 8 percent serum solids sample.

The outstanding sample of the group was the 14 percent fat, 10 percent serum solids sample.

The national collegiate score card for judging ice cream now recognizes the melting quality of ice cream as one of the points to be considered in judging body and texture of ice cream. Although definite numerical evaluations as regards melting quality defects are not available as yet, the new score card lowers the body and texture score of samples of ice cream which resist melting, appear frothy or "whey off." A perfect melting sample is one which melts readily, leaves no sign of froth and does not "whey off." The melted portion should look like the original mix. It is for this reason that photographs indicating the melting quality of the mixes were included in this paper. No cut in the body and texture scores was made, however, on the basis of melting quality. Ice creams which contained sodium caseinate sol had better melting qualities than did the regular mixes, despite the fact that they might have been criticized for the bubble formation previously mentioned. This defect, however, was not particularly apparent in the 2 and 3 percent sodium caseinate replacement samples, and when it appeared in any of the samples it was after such periods of time as would not be encountered in samples that melted under normal conditions of consumption.

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